PUTTING RESEARCH TO WORK

BRIEF

Designing Concrete Pavements to Withstand Heavy Loads

In 2001, a Wisconsin Department of Transportation soils engineer filed a Report of Early Distress on two sections of highway that had exhibited significant longitudinal cracking within two to four years of installation. The 6.5-mile stretch of US 8 and 8-mile section of US 51 near Rhinelander were constructed of jointed plain concrete pavement, with 9-inch dowels at randomly spaced, skewed joints, over a 6-inch dense-graded base course. The culprits cited in the RED were overloading by logging trucks, and low flexural strength values in the pavements' design.

What's the Problem?

Current WisDOT design procedures for jointed concrete pavements are based on the 1972 AASHTO pavement design guide, which was revised in 1981. These procedures do not include criteria for anticipating overloading.

WisDOT is not alone. Of the dozens of transportation agencies examined in this study, only Iowa DOT addresses overloading during pavement design, specifying a traffic load factor of 1.2 to anticipate heavy loads like those from logging operations. Though the 2002 AASHTO Mechanistic-Empirical Pavement Design Guide will address overloading, its refinement and implementation remain years away.

Research Objectives

Investigators sought to help WisDOT address overloading in jointed plain concrete pavement by identifying the most economical and efficient design procedure for concrete pavements subject to heavier than normal truck loading. The selected procedure would be required to provide an easy transition to the 2002 AASHTO guide, and to accommodate a variety of rehabilitation methods for in-service JPCP.

Methodology

Through a literature search and a survey of agencies with climates similar to Wisconsin's, researchers identified feasible design methods. Investigators gathered design procedures from 24 states and four Canadian provinces that use portland cement concrete and have frost conditions similar to Wisconsin's. Of the agencies surveyed, 21 use the 1993 AASHTO Guide for Design of Pavement Structures for JPCP design. Though pavement engineers widely favor the Portland Cement Association procedures for their mechanistic integrity, only Iowa uses the PCA method exclusively, and Quebec uses it along with the 1993 AASHTO guide.

Investigators selected the 1993 AASHTO guide and the PCA method for further evaluation. They assessed these methods for their sufficiency in addressing overloading, providing a transition to the 2002 AASHTO guide, and providing guidelines for rehabilitation of existing JPCP.

Results

Researchers recommend that WisDOT adopt the 1993 AASHTO design guidelines for jointed plain concrete pavement. They found the 1993 AASHTO guide to be preferable to the PCA method in the three areas evaluated:

• **Addressing overloading.** The PCA method applies safety factors of 0% to 20% to each axle load range, while the 1993 AASHTO guide addresses uncertainty such as overloading through probabilistic design concepts that reflect the amount of statistical variability associated with parameters in the design process, ultimately focusing on design reliability. This is considered a more realistic approach.

• **Providing a transition to the 2002 AASHTO guide.** The 1993 AASHTO guide employs more concepts (including design reliability) and terminology that will be used in the 2002 AASHTO guide than the PCA method does.

Investigator

"We're recommending that WisDOT move to the 1993 AASHTO design guide, which addresses overloading and provides a transition to the 2002 design guide."

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Heavy trucks subject highways to loads not currently anticipated in Wisconsin concrete pavement design procedures. These Class 9 logging trucks were photographed along US 8 near Rhinelander.

• **Providing guidelines for rehabilitation of existing JPCP.** The 1993 AASHTO guide outlines procedures for designing structural overlays of existing JPCP; the PCA procedure does not.

Researchers then evaluated the 1993 AASHTO guide using data from the logging truck corridor along US 8 near Rhinelander, and compared their findings with current WisDOT design procedures. The results indicated that applying higher than normal reliability values in conjunction with modified rigid load factors during pavement design has the greatest potential to address overloading on Wisconsin's concrete pavements.

The final report includes suggested design input values for reliability, load and other parameters for use with the 1993 AASHTO guide until WisDOT can develop values for local conditions. It also includes procedures and suggested input parameters for asphaltic overlays of existing JPCP and rubblized or crack-and-seat JPCP, as well as for unbonded JPCP overlays.

This research also provided a valuable look at other states' practices in concrete pavement design. In comparison to other agencies, WisDOT's rigid equivalent single axle load factor values were found to be relatively low for FHWA vehicle classes 5, 8 and 9. In addition, in thickness design, only Wisconsin and two other states use strength parameters based on compressive strength; all other agencies use flexural strength parameters.

Benefits

WisDOT's adoption of the 1993 AASHTO guide will facilitate a smooth transition to the 2002 AASHTO guide. The 1993 guide is well-suited to heavily loaded concrete pavements, and will help promote longer service lives for JPCP. More precise pavement design that accommodates overloading will help WisDOT make better use of limited resources such as aggregate, and should reduce pavement maintenance costs.

Further Research

Although this report provides suggested design inputs for interim use with the 1993 AASHTO guide, further study is needed to determine design input values such as load factors and reliability values for local conditions in Wisconsin. Adoption of the 1993 AASHTO guide will also impact flexible pavement design procedures, and will require research similar to this project with a particular focus on load factors.

This brief summarizes Project 0092-05-06, "Effects of Heavy Loading on Wisconsin's Concrete Pavements," produced through the Wisconsin Highway Research Program for the Wisconsin Department of Transportation Research, Development & Technology Transfer Program, 4802 Sheboygan Ave., Madison, WI 53707.

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Project Manager

"WisDOT is currently using the 1972 AASHTO design method for concrete pavements. For most pavements, this method has been adequate, but it does not accommodate overloading."

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